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Information technology — Process assessment — Process measurement framework for assessment of process capability

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Contents

Page

Foreword ..... **iv**
Introduction ..... **v**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Overview **2**
5 A process measurement framework for process capability **2**
5.1 Introduction 2
5.2 Process capability levels and process attributes 2
5.2.1 Process capability Level 0: Incomplete process 2
5.2.2 Process capability Level 1: Performed process 2
5.2.3 Process capability Level 2: Managed process 3
5.2.4 Process capability Level 3: Established process 4
5.2.5 Process capability Level 4: Predictable process 4
5.2.6 Process capability Level 5: Innovating process 5
5.3 Process attribute rating scale 6
5.4 Process attribute rating method 7
5.4.1 Rating method R1 7
5.4.2 Rating method R2 8
5.4.3 Rating method R3 8
5.5 Aggregation method 8
5.5.1 One dimensional aggregation methods 9
5.5.2 Two dimensional aggregation methods 9
5.6 Process capability level model 9
Annex A (informative) **Conformity of the process measurement framework** **11**
Annex B (informative) **Example of a process performance model** **16**
Bibliography **18**

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 7, *Software and systems engineering*.

This second edition cancels and replaces Clause 5 of ISO/IEC 15504-2:2004, which has been technically revised.

Introduction

This International Standard defines a process measurement framework for the process quality characteristic of process capability. The process measurement framework in this International Standard conforms to the requirements of ISO/IEC 33003 and is applicable to any domain. The process measurement framework can be included in any process assessment model for the assessment of process capability, as specified in ISO/IEC 33004.

This International Standard is primarily addressed to developers of process assessment models for the process quality characteristic of process capability. It is also addressed to the lead assessor and other stakeholders, such as the sponsor of the assessment, who need to be assured that the requirements of this process measurement framework have been met.

This International Standard is part of a set of International Standards designed to provide a consistent and coherent framework for the assessment of process quality characteristics, based on objective evidence resulting from implementation of the processes. The framework for assessment covers processes employed in the development, maintenance and use of systems across the information technology domain and those employed in the design, transition, delivery and improvement of services. The set of International Standards, as a whole, addresses process quality characteristics of any type. Results of assessment can be applied for improving process performance, benchmarking, or for identifying and addressing risks associated with application of processes.

The set of International Standards ISO/IEC 33001 to ISO/IEC 33099, termed the ISO/IEC 330xx family, defines the requirements and resources needed for process assessment. The overall architecture and content of the series is described in ISO/IEC 33001. General issues relating to the application of conformity assessment to the assessment of process quality characteristics and organizational process maturity are addressed in ISO/IEC 29169.

Several Standards in the ISO/IEC 330xx family of standards for process assessment are intended to replace and extend parts of the ISO/IEC 15504 series of Standards. This International Standard is intended to replace Clause 5 of ISO/IEC 15504-2:2004. ISO/IEC 33001:2014, Annex A provides a detailed record of the relationship between the ISO/IEC 330xx family and the ISO/IEC 15504 series.

Information technology — Process assessment — Process measurement framework for assessment of process capability

1 Scope

This International Standard defines a process measurement framework that supports the assessment of process capability, in accordance with the requirements of ISO/IEC 33003. The process measurement framework provides a schema that can be used to construct a process assessment model conformant with ISO/IEC 33004[4] which can be used in the performance of assessment of process capability according to the requirements of ISO/IEC 33002[3]. In the context of this and related standards, process capability is a process quality characteristic related to the ability of a process to consistently meet current or projected business goals.

The process measurement frameworks defined in this International Standard form a structure which

a) facilitates self-assessment,

b) provides a basis for use in process improvement and process quality determination,

c) is applicable across all application domains and sizes of organization,

d) produces a set of process (capability) attribute ratings (process profile), and

e) derives a process capability level.

NOTE Copyright release: Users of this International Standard may reproduce subclauses 5.2, 5.3, 5.4 and 5.6 as part of any process assessment model or maturity model so that it can be used for its intended purpose.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 33001, *Information technology — Process assessment — Concepts and terminology*

ISO/IEC 33003, *Information technology — Process assessment — Requirements for process measurement frameworks*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 33001 and the following apply.

3.1
process capability
characterization of the ability of a process to meet current or projected business goals

3.2
process capability level
characterisation of a process on an ordinal measurement scale of process capability

4 Overview

The capability to perform a process to a specific level of performance depends on well established principles. This International Standard sets out those principles that are common to all domains. The process capability measurement framework described in this International Standard is expressed in terms of a set of process attributes. Each process attribute is defined in terms of a set of process attribute outcomes which can be evaluated to indicate the extent of achievement of the process attribute. The process attributes are organised into process capability levels, ranging from Incomplete (in which the process does not achieve its defined process outcomes) to Innovating (in which the process is continually improved to respond to organizational change).

The result of an assessment, using a process assessment model that incorporates this process measurement framework, will be a set of process profiles - ratings of the achievement of the set of process attributes for each process in the scope of the assessment. The result can also be expressed in terms of the capability level ratings achieved for each process in the assessment scope. A capability level rating does not guarantee that an organization will perform its processes at any given process capability level, simply that it is capable of performing its processes at that level.

5 A process measurement framework for process capability

5.1 Introduction

This clause defines a process measurement framework for the assessment of process capability, conformant with the requirements of ISO/IEC 33003. This process measurement framework provides a schema that can be used to construct a process assessment model for assessing process capability.

Within this process measurement framework, the measure of capability is based upon a set of process attributes. Each process attribute defines a measurable property of process capability. The extent of process attribute achievement is characterised on a defined rating scale. The process capability level for an assessed process is derived from the set of process attribute ratings represented in the process profile.

The achievement of one process attribute may be associated with the achievement of another process attribute within the process measurement framework.

5.2 Process capability levels and process attributes

Process capability is defined on a six point ordinal scale that enables capability to be assessed from the bottom of the scale, **Incomplete**, through to the top end of the scale, **Innovating**. The scale represents increasing capability of the implemented process, from failing to achieve the process purpose through to continually improving and able to respond to organizational change.

5.2.1 Process capability Level 0: Incomplete process

The process is not implemented, or fails to achieve its process purpose.

At this level there is little or no evidence of any systematic achievement of the process purpose.

5.2.2 Process capability Level 1: Performed process

The implemented process achieves its process purpose. The following process attribute demonstrates the achievement of this level.

5.2.2.1 PA 1.1 Process performance process attribute

The process performance process attribute is a measure of the extent to which the process purpose is achieved. As a result of full achievement of this process attribute:

a) The process achieves its defined process outcomes.

5.2.3 Process capability Level 2: Managed process

The previously described *Performed process* is now implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained.

The following process attributes, together with the previously defined process attribute, demonstrate the achievement of this level:

5.2.3.1 PA 2.1 Performance management process attribute

The performance management process attribute is a measure of the extent to which the performance of the process is managed. As a result of full achievement of this process attribute:

a) Objectives for the performance of the process are identified;

b) Performance of the process is planned;

c) Performance of the process is monitored;

d) Performance of the process is adjusted to meet plans;

e) Responsibilities and authorities for performing the process are defined, assigned and communicated;

f) Personnel performing the process are prepared for executing their responsibilities;

g) Resources and information necessary for performing the process are identified, made available, allocated and used;

h) Interfaces between the involved parties are managed to ensure both effective communication and clear assignment of responsibility.

5.2.3.2 PA 2.2 Work product management process attribute

The work product management process attribute is a measure of the extent to which the work products produced by the process are appropriately managed. As a result of full achievement of this process attribute:

a) Requirements for the work products of the process are defined;

b) Requirements for documentation and control of the work products are defined;

c) Work products are appropriately identified, documented, and controlled;

d) Work products are reviewed in accordance with planned arrangements and adjusted as necessary to meet requirements.

NOTE 1 Requirements for documentation and control of work products may include requirements for the identification of changes and revision status, approval and re-approval of work products, distribution of work products, and for making relevant versions of applicable work products available at points of use.

NOTE 2 The work products referred to in this Clause are those that result from the achievement of the process purpose through the process outcomes.

5.2.4 Process capability Level 3: Established process

The previously described *Managed process* is now implemented using a defined process that is capable of achieving its process outcomes.

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

5.2.4.1 PA 3.1 Process definition process attribute

The process definition process attribute is a measure of the extent to which a standard process is maintained to support the deployment of the defined process. As a result of full achievement of this process attribute:

a) A standard process, including appropriate tailoring guidelines, is defined and maintained that describes the fundamental elements that must be incorporated into a defined process;

b) The sequence and interaction of the standard process with other processes is determined.

c) Required competencies and roles for performing the process are identified as part of the standard process;

d) Required infrastructure and work environment for performing the process are identified as part of the standard process;

e) Suitable methods and measures for monitoring the effectiveness and suitability of the process are determined.

5.2.4.2 PA 3.2 Process deployment process attribute

The process deployment process attribute is a measure of the extent to which the standard process is deployed as a defined process to achieve its process outcomes. As a result of full achievement of this process attribute:

a) A defined process is deployed based upon an appropriately selected and/or tailored standard process;

b) Required roles, responsibilities and authorities for performing the defined process are assigned and communicated;

c) Personnel performing the defined process are competent on the basis of appropriate education, training, and experience;

d) Required resources and information necessary for performing the defined process are made available, allocated and used;

e) Required infrastructure and work environment for performing the defined process are made available, managed and maintained;

f) Appropriate data are collected and analysed as a basis for understanding the behaviour of the process, to demonstrate the suitability and effectiveness of the process, and to evaluate where continual improvement of the process can be made.

5.2.5 Process capability Level 4: Predictable process

The previously described *Established process* now operates predictively within defined limits to achieve its process outcomes. Quantitative management needs are identified, measurement data are collected and analysed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

5.2.5.1 PA 4.1 Quantitative analysis process attribute

The quantitative analysis process attribute is a measure of the extent to which information needs are defined, relationships between process elements are identified and data are collected. As a result of full achievement of this process attribute:

a) The process is aligned with quantitative business goals;

b) Process information needs in support of relevant defined quantitative business goals are established;

c) Process measurement objectives are derived from process information needs;

d) Measurable relationships between process elements that contribute to the process performance are identified;

e) Quantitative objectives for process performance in support of relevant business goals are established;

f) Appropriate measures and frequency of measurement are identified and defined in line with process measurement objectives and quantitative objectives for process performance;

g) Results of measurement are collected, validated and reported in order to monitor the extent to which the quantitative objectives for process performance are met.

NOTE 1 Information needs typically reflect management, technical, project, process or product needs.

NOTE 2 Measures may be either process measures or product measures or both.

5.2.5.2 PA 4.2 Quantitative control process attribute

The quantitative control process attribute is a measure of the extent to which objective data are used to manage process performance that is predictable. As a result of full achievement of this process attribute:

a) Techniques for analysing the collected data are selected;

b) Assignable causes of process variation are determined through analysis of the collected data;

c) Distributions that characterize the performance of the process are established;

d) Corrective actions are taken to address assignable causes of variation;

e) Separate distributions are established (as necessary) for analysing the process under the influence of assignable causes of variation.

5.2.6 Process capability Level 5: Innovating process

The previously described *Predictable process* is now continually improved to respond to change aligned with organizational goals.

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level:

5.2.6.1 PA 5.1 Process innovation process attribute

The process innovation process attribute is a measure of the extent to which changes to the process are identified from investigations of innovative approaches to the definition and deployment of the process. As a result of full achievement of this process attribute:

a) Process innovation objectives are defined that support the relevant business goals;

b) Appropriate data are analysed to identify opportunities for innovation;

c) Innovation opportunities derived from new technologies and process concepts are identified;

d) An implementation strategy is established to achieve the process innovation objectives.

5.2.6.2 PA 5.2 Process innovation implementation process attribute

The process innovation process implementation attribute is a measure of the extent to which changes to the definition, management and performance of the process achieves the relevant process innovation objectives. As a result of full achievement of this process attribute:

a) Impact of all proposed changes is assessed against the objectives of the defined process and standard process;

b) Implementation of all agreed changes is managed to ensure that any disruption to the process performance is understood and acted upon;

c) Effectiveness of process change on the basis of actual performance is evaluated against the defined product requirements and process objectives.

5.3 Process attribute rating scale

Within this process measurement framework, a process attribute is a measureable property of process capability. A process attribute rating is a judgement of the degree of achievement of the process attribute for the assessed process.

A process attribute is measured using an ordinal scale as defined below.

N Not achieved:

There is little or no evidence of achievement of the defined process attribute in the assessed process.

P Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.

L Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.

F Fully achieved:

There is evidence of a complete and systematic approach to, and full achievement of, the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.

The ordinal scale defined above shall be understood in terms of percentage achievement of a process attribute.

The corresponding percentages shall be:

N Not achieved 0 to ≤15% achievement

P Partially achieved > 15% to ≤50% achievement

L Largely achieved > 50% to ≤85% achievement

F Fully achieved > 85% to ≤100% achievement

The ordinal scale may be further refined for the measures P and L as defined below.

P+ Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.

P- Partially achieved:

There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Many aspects of achievement of the process attribute may be unpredictable.

L+ Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.

L- Largely achieved:

There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Many weaknesses related to this process attribute may exist in the assessed process.

The corresponding percentages shall be:

P-	Partially achieved -	>15% to ≤ 32.5% achievement
P+	Partially achieved+	>32.5 to ≤50% achievement
L-	Largely achieved-	> 50% to ≤67.5% achievement
L+	Largely achieved+	>67.5% to ≤85% achievement

5.4 Process attribute rating method

A process outcome is the observable result of successful achievement of the process purpose.

A process attribute outcome is the observable result of achievement of a specified process attribute.

Process outcomes and process attribute outcomes may be characterised as an intermediate step to providing a process attribute rating.

When performing rating, the rating method employed shall be specified relevant to the class of assessment. The following rating methods are defined.

The use of rating method may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) rating method to use. The selected rating method(s) shall be specified in the assessment input and referenced in the assessment report.

5.4.1 Rating method R1

The approach to process attribute rating shall satisfy the following conditions:

a) Each process outcome of each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) Each process attribute outcome of each process attribute for each process within the scope of the assessment shall be characterised for each process instance, based on validated data;

c) Process outcome characterisations for all assessed process instances shall be aggregated to provide a process performance attribute achievement rating;

d) Process attribute outcome characterisations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

5.4.2 Rating method R2

The approach to process attribute rating shall satisfy the following conditions:

a) Each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;

b) Process attribute characterisations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.

5.4.3 Rating method R3

Process attribute rating across assessed process instances shall be made without aggregation.

5.5 Aggregation method

When performing an assessment, ratings may be summarised across one or two dimensions.

For example, when rating a

— process attribute for a given process, one may aggregate ratings of the associated process (attribute) outcomes – such an aggregation will be performed as a vertical aggregation (one dimension).

— process (attribute) outcome for a given process attribute across multiple process instances, one may aggregate the ratings of the associated process instances for the given process (attribute) outcome - such an aggregation will be performed as a horizontal aggregation (one dimension)

— process attribute for a given process, one may aggregate the ratings of all the process (attribute) outcomes for all the processes instances – such an aggregation will be performed as a matrix aggregation across the full scope of ratings (two dimensions)

The use of aggregation of ratings may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) aggregation method to use. The selected aggregation method(s) shall be specified in the assessment input and referenced in the assessment report.

As described in 5.3, process attributes are rated using an ordinal scale. The assessor may choose to apply expert judgement to summarize the ratings without employing a formal mathematical approach, alternatively an aggregation method may be used. An aggregation approach requires that the ordinal ratings be converted to interval values in order to perform aggregation. The validity of this conversion from ordinal ratings to interval values is dependent on two conditions[1]:

a) The ordinal scale must be sufficiently constrained that the ordinal values are reasonably evenly spread. The rating scale defined in this international standard meets the requirement of being evenly spread;

b) There must be evidence of adequate sample size to assure adequate accuracy of the ordinal values. This condition is met for class 1 and class 2 assessments, both of which are sufficiently rigorous to require an adequate sample size.

Since these conditions are met, then the ordinal ratings can be converted to interval values as follows:

N -> 0; P -> 1; L -> 2; F -> 3 or

N -> 0; P- -> 1; P+ -> 2; L- -> 3; L+ -> 4; F -> 5

5.5.1 One dimensional aggregation methods

Having converted the ordinal ratings to interval values, one of the following one dimensional aggregation methods may be used to obtain a summary rating.

5.5.1.1 One dimensional aggregation using arithmetic mean

Aggregation may be performed by computing the arithmetic mean (average) of the ratings of the interval values, rounding the result to the nearest integer (by rounding up or down), and converting the result back to the corresponding ordinal rating. When rounding is necessary the interval value will be rounded down to the nearest integer when the average value is less than the midpoint between consecutive integers; it will be rounded up if the average value is at or above the midpoint between consecutive integers.

5.5.1.2 One dimensional aggregation using median

Aggregation may be performed by computing the median (middle value) of the ratings of the interval values, the given data is arranged in order from lowest to highest. If there is an odd number of data then the median is the middle value. If there is an even number of data then the two middle values are selected and the arithmetic mean (average) taken. If there is an even number of ratings and the process of taking an average of the two middle values results in real number, then the number is rounded to an integer value using the rules above.

NOTE The operation of taking the mean is mathematically valid since we are dealing with interval data.

5.5.2 Two dimensional aggregation methods

In an assessment when there are multiple process instances being assessed, then it may be necessary to summarize the ratings across two dimensions.

For example, for a given process, the process outcomes of several process instances assessed may be aggregated to form an overall process attribute rating.

As noted in 5.5.1, this may be accomplished using the expert judgement of the assessor(s) or it may be accomplished using an aggregation method. Use of expert judgement should not be ruled out since there may be situations where a small number of process instances may be outliers (for example, projects initiated before a process improvement project, or when a small number of projects do not support the rigour of a formal process). Having converted the ordinal ratings to interval values, one of the following two dimensional aggregation methods may be used to obtain a summary rating.

5.5.2.1 Two dimensional aggregation using arithmetic mean

Aggregation may be performed by computing the arithmetic mean across the matrix of the full scope of ratings (expressed as numeric interval values) and converting the result back to the corresponding ordinal rating.

NOTE It is not permitted, when performing aggregation, to take an average of averages since such an approach is not statistically valid.

5.5.2.2 Two dimensional aggregation using heuristics

Aggregation may be performed using a defined set of rules to summarise the ratings. For example Table 1.

5.6 Process capability level model

The process capability level achieved by a process shall be derived from the process attribute ratings for that process according to the process capability level model defined in Table 1.

Table 1 — Process capability level ratings

Scale	Process attributes	Rating
Level 1	Process Performance	Largely or fully
Level 2	Process Performance	Fully
	Performance Management	Largely or fully
	Work Product Management	Largely or fully
Level 3	Process Performance	Fully
	Performance Management	Fully
	Work Product Management	Fully
	Process Definition	Largely or fully
	Process Deployment	Largely or fully
Level 4	Process Performance	Fully
	Performance Management	Fully
	Work Product Management	Fully
	Process Definition	Fully
	Process Deployment	Fully
	Quantitative Analysis	Largely or fully
	Quantitative Control	Largely or fully
Level 5	Process Performance	Fully
	Performance Management	Fully
	Work Product Management	Fully
	Process Definition	Fully
	Process Deployment	Fully
	Quantitative Analysis	Fully
	Quantitative Control	Fully
	Process Innovation	Largely or fully
	Process Innovation Implementation	Largely or fully

Annex A
(informative)

Conformity of the process measurement framework

A.1 Conformance requirements

The following requirements for a process measurement framework are drawn from ISO/IEC 33003 which provides normative requirements for process measurement frameworks. Where text has been quoted from ISO/IEC 33003, that text is enclosed in a box, for ease of identification.

A.1.1 Conceptualization

A process capability level is characterised by one or more process attributes, which are formative measures of the process capability. Process attributes are required in order to construct the process capability. Process attributes are demonstrated by achievement of the process attribute outcomes, which are reflective measures.

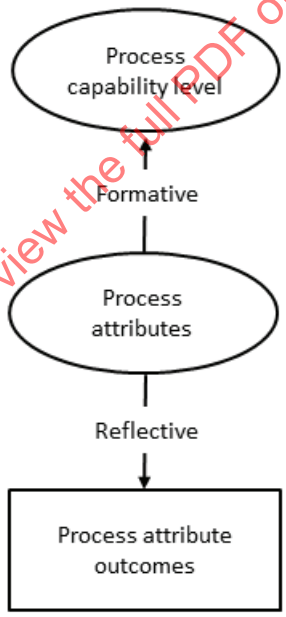

Figure A.1 — Formative and reflective measures of process capability

The concept of process capability does not provide a measure of anything other than process capability formed by process attributes. For example, process capability does not infer anything about organizational performance.

a) A process measurement framework shall identify and address a single process quality characteristic;

   The measurement framework is defined for the single process quality characteristic of software quality

b) A process quality characteristic in a process measurement framework shall be defined on the basis of a multidimensional construct which consists of a set of unidimentional constructs;

   The process measurement framework is a construct comprised of nine process attributes.

c) A process quality characteristic in a process measurement framework shall be defined as a set of process attributes;

The process measurement framework is a construct comprised of nine process attributes.

d) Each process attribute shall define a property of the process quality characteristic;

The property defined by each process attribute is described in Clause 5.

e) Each process attribute that is not directly measurable shall be considered as a construct;

Each process attribute in this measurement framework is a construct and defined in Clause 5.

f) Process attributes in a process measurement framework shall be defined as either reflective or formative.

The process attributes of this measurement framework are formative

g) The process measurement framework shall document the policies and assumptions underlying its use and application;

The policies and assumptions underlying the use and application of this process measurement framework are set out in Clauses 1, 4, and 5.

A.1.2 Construct definition

a) The construct definition shall define the meaning of the process quality characteristic and its process attributes in a process measurement framework;

The meaning of the process quality characteristic and its process attributes are given in Clause 5

b) The construct definition shall clarify the specification of the process quality characteristic and its process attributes as dimensions;

The specifications of the process quality characteristic and its process attributes are given in Clause 5

c) The construct definition shall provide a guide for the operationalization of the process quality characteristic and its process attributes;

Operationalization of the process quality characteristic and its process attributes is given in Clause 5

d) The construct definition shall state the scales of composite measures such as categorical (e.g., a series of ordinal values such as capability level) or numeric;

The scales of composite measures in this measurement framework are given in Clause 5.

e) At least one of the process attributes shall comprise the achievement of the defined process purpose and process outcomes for the process; this is termed the process performance attribute;

The process performance attribute (PA 1.1) comprises the achievement of the defined process purpose through achievement of the process outcomes for that process.

A.1.3 Operationalization

a) All process attributes shall be defined according to their construct specification;

The process attributes are defined in 5.2; the descriptions follow a common approach, described in 5.1.

b) Achievement of process attributes shall be verifiable through objective evidence.

In the process performance attribute, the achievement of process outcomes is demonstrable based on objective evidence. In all other process attributes, the achievement of the attribute is demonstrable on the basis of objective evidence, employing the process attribute outcomes as base measures.

A.1.4 Construct specification examination

Construct specifications of the process quality characteristic and its associated process attributes shall be examined through operationalization and with rationale.

Each Process Attribute is operationalized through a set of base or derived measures depending on the class of assessment. See 5.3.3.

A.1.5 Rating process attributes

a) The process attributes shall be rated;

The unit of measurement is specified in 5.3.

b) A measurement scale, i.e., nominal, ordinal, interval, or ratio, shall be defined for the process attributes

The measurement scale for base measures are ordinal, defined in 5.3.

c) A measurement method shall be identified that objectively assigns value to each measure.

The method for assigning a value to the measure of process capability is described in 5.3.

A.1.6 Aggregation

a) All aggregations required within the measurement framework shall be identified;

Aggregation methods are defined in 5.5.

b) Aggregation methods shall be specified;

Aggregation methods are defined in 5.5.

c) Aggregation methods shall be statistically valid.

Rationales for the validity of aggregation methods in this international standard are given in 5.5.

d) Aggregation methods shall utilize consistent measurement scales;

The aggregation methods use consistent scales, described in 5.5

e) Aggregation methods shall be consistent with the measurement framework policies and assumptions;

f) Aggregation methods shall be consistent with construct specifications.

Consistency with policies and assumptions, and with the construct specifications is described in 5.5.

A.1.7 Sensitivity analysis

a) Sensitivity analysis shall be performed for measurement scales of base and derived measures.

Sensitivity of the process capability scale was tested during the SPICE Trials[5,6]. The investigations included inter-rater agreement and internal consistency, both of which were found to be acceptable. The possibility of increasing internal consistency was investigated by varying the four category scale to a three or two category scale by combining either the middle two ratings (N, (P, L), F) or the

outer two ratings ((N, P), (L, F)). The current four category scale cannot be improved by reduction to a three or two category scale.

Sensitivity of process capability level ratings was investigated during the SPICE Trials and reported in the Interim Report[7]. Overall the investigation concluded that distortion downward of the capability level rating had greater effect than distortion upwards, but that guidance should be provided to assessors concerning the potential effects of distortion.

b) Sensitivity analysis shall be performed for aggregation methods;

Some sensitivity analysis data related to aggregation is available in the SPICE Trials reports[6,7], however its relevance to the current approach is limited. The issue of aggregation was examined in detail during the development of the International Standard.

c) Sensitivity analysis shall be performed for weights, if applicable.

Weights are not used in this measurement framework so are not applicable.

A.2 Requirements for the validation of process measurement frameworks

A.2.1 Reliability and validity

a) Plans for reliability and validity of process measurement frameworks shall be established at the beginning of standardization. These plans shall include post-standardization activities;

b) Claims on reliability and validity of process measurement frameworks shall be consistent with construct specification;

c) Consistency (also refers to equivalence) as a reliability measure shall be examined for process attributes, if reflective;

d) Validities shall be examined for the process quality characteristic and its process attributes in a process measurement framework;

e) Construct specification shall be empirically examined for the process quality characteristic and its measures in a process measurement framework;

f) External measures (e.g., goals, criteria, and/or achievements) of a process measurement framework under development shall be documented for validity investigation.

Validation was performed during the SPICE trials conducted during standard development.

The measurement method and capability scale were tested during the SPICE trials. There has been no change to the concepts of the measurement scale that would invalidate the process capability scale or the findings of the trial.

A.3 Conformance

A process measurement framework shall be in conformity with the requirements of this International Standard

When data are available during trials and/or after the publication of a framework, rigorous statistical analyses will be required for all the applicable requirements.

The results of such analyses are referred to when meeting the requirements in A.1 and A.2 and are documented in the following references:

- H.-W. Jung, et al., “Findings from Phase 2 of the SPICE trials,” Software Process: Improvement and Practice, vol. 6, pp. 205-242, 2001[5].
- SPICE Trials (1999), SPICE Phase 2 Trials Final Report, ISO/IEC/JTC1/SC7/WG10[6].